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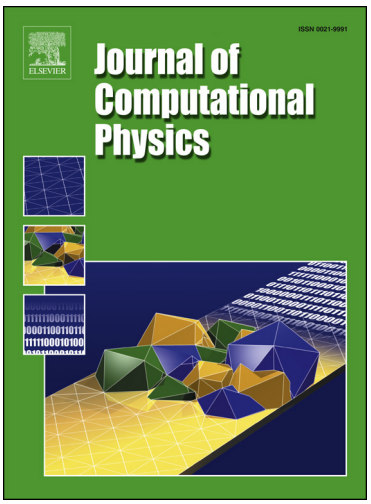

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A Correction Function Method for the Wave Equation with Interface Jump Conditions

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Abstract

In this paper a novel method to solve the constant coefficient wave equation, subject to interface jump conditions, is presented. In general, such problems pose issues for standard finite difference solvers, as the inherent discontinuity in the solution results in erroneous derivative information wherever the stencils straddle the given interface. Here, however, the recently proposed Correction Function Method (CFM) is used, in which correction terms are computed from the interface conditions, and added to affected nodes to compensate for the discontinuity. In contrast to existing methods, these corrections are not simply defined at affected nodes, but rather generalized to a continuous function within a small region surrounding the interface. As a result, the correction function may be defined in terms of its own governing partial differential equation (PDE) which may be solved, in principle, to arbitrary order of accuracy. The resulting scheme is not only arbitrarily high order, but also robust, having already seen application to Poisson problems and the heat equation. By extending the CFM to this new class of PDEs, the treatment of wave interface discontinuities in homogeneous media becomes possible. This allows, for example, for the straightforward treatment of infinitesimal source terms and sharp boundaries, free of staircasing errors. Additionally, new modifications to the CFM are derived, allowing compatibility with explicit multi-step methods, such as Runge-Kutta (RK4), without a reduction in accuracy. These results are then verified through numerous numerical experiments in one and two spatial dimensions.

Keywords: Wave Equation, Correction Function Method, Interface Jump, High Order, Maxwell's Equations, Immersed Method.